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A NOVEL MOUNT FOR USE WITH MOLECULAR BEAM SKIMMER-BASED LIGHT BAFFLES

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U.S. ARMY LABORATORY COMMAND

BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

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One of the most troublesome problems in LIF experiments currently being performed in our laboratory to expand the spectral database on species relevant to propellant combustion is the appearance of unwanted, scattered laser light at the detector. This problem can severely reduce the overall sensitivity of the system and preclude experiments. One way to largely alleviate the problem is through the use of light baffles as designed by J. E. Butler of the Naval Research Laboratories. However, the design of mounts for these baffles is not a simple matter because of several problems including alignment of multiple baffles through which the laser beam must pass and fragility of the baffles. This report presents a simple mount which we have designed to overcome all of these problems. The mount is easy to make, may be stacked if multiple baffles are desired, and protects the baffles from damage while removed from the vacuum system.

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1. INTRODUCTION

Ultraviolet and visible optical techniques are frequently used in our laboratory to probe combusting propellants and other flames. The database of spectral constants necessary for interpreting the results of these experiments comes from the literature and from our own experiments. In our experiments, the species of interest is formed in a vacuum system flow cell under more controlled conditions than in the flames and interrogated using laser-induced fluorescence (LIF). One of the major difficulties encountered in such flow cell-based LIF experiments is the noise produced as a result of scattered laser light. As is well known, the light scattered from a number of surfaces in an apparatus such as a flow cell severely limits the sensitivity of the detection system. One technique to significantly reduce the scattered laser light is the use of light baffles such as designed by J.E. Butler of the Naval Research Laboratory (Butler 1982). Based on the skimmers used in a molecular beam apparatus, his design offers a significant improvement in S/N over the traditionally employed flat iris-type baffles. (A factor of 10^2–10^3 reduction in laser scatter and window fluorescence reaching the detector is common.) The baffles are thin, metallic shells of a slightly curved conical shape (see Figure 1); the tip is removed in such a way as to provide a circular orifice with a razor-sharp edge. The laser beam passes through this orifice, but off-axis stray light is rejected, as shown in Figure 1.

We recently obtained a large quantity of these baffles for use in our flow cell-based experiments. However, since these baffles are electroformed (electrically plated onto a metal form) to a thin breadth from copper, they are relatively fragile. Thus, the problem of how to mount and align a single baffle, let alone a stack or array of baffles, becomes nontrivial.

2. DESIGN OF MOUNTS

The most obvious solution to the problem outlined above is to affix the base of each baffle to a larger diameter washer with an adhesive suitable for use at low pressures; the washers are then mounted and spaced on metallic rods. In practice, it becomes clear that this method

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Butler, J. E. "Efficient Baffles for Laser Light Scattering Experiments." App. Opt., vol. 21, p. 3617, 1982.

creates three problems. First, there are alignment difficulties. Since a stack of several baffles is generally used, both the washers and the baffles must be carefully aligned upon initial assembly—a difficult task. Second, since an adhesive is used, the baffles may not be readily demounted and adjustments are not easily made. At the very least, it becomes an inconvenience when a change or replacement is required and realignment is necessary. Third, stray light may slip around the washer assembly.

We report a design for a light baffle mount that solves all of these problems. Design criteria were based on the dimensions of a standard stainless steel vacuum nipple in which the baffles and their mounts would be contained (O.D., 1.5 in [3.81 cm]; I.D., 1.375 in [3.49 cm]; length, 6 in [15.24 cm]; with 2.75 in [6.99 cm] conflat flanges) and the overall dimensions of the light baffles we had in our possession. Such a nipple is essentially just a straight piece of pipe with vacuum flanges at the ends. The size nipple we used is a typical building block for vacuum systems and is available from a number of companies that supply vacuum equipment. Two of these nipples through which laser beams are passed are attached

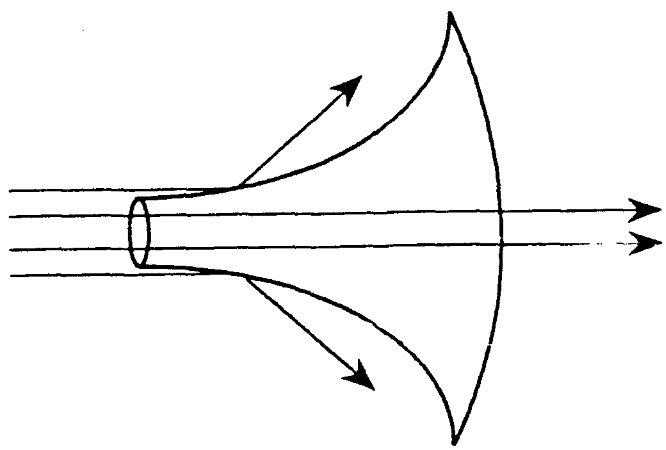

Figure 1. Light Baffle. The Baffle Is Shown Here in Its Intended Usage to Pass the Central Portion of a Laser Beam and Reject the Outer Portion. When Several of These Are Placed Along a Laser Beam, Light Rays Angled Away From the Direction of the Laser Beam Are Also Rejected by the Baffles.

on either side of a six-port stainless steel cross in which LIF samples are interrogated. The specific information regarding minor and major diameters, radius of curvature, etc., for the baffles can be found in Butler (1982).

The mount to be described actually refers to a set of two components—the holder in which the baffle resides and a retaining ring which fixes the baffle in place (Figures 2 and 3). All parts were fabricated from aluminum round stock. Therefore, the costs were relatively low and the difficulty associated with the material was minimal. If a computer controlled lathe is available, these parts can be produced in "cookie cutter" fashion.

The first mount was fabricated with a nipple and a light baffle on hand in order to best determine acceptable tolerances for some of its dimensions. The light baffle rests on a ledge machined through the center of the mount (see Figure 3). The width of the ledge is sufficient to accommodate a variety of major baffle diameters. This is necessary because the electroforming process had a tendency to produce major diameters of slightly varying size. This aspect is of minimal concern because the radius of curvature, aperture size, and razor-like edge requirement of the minor diameter are of primary importance in reducing the amount of scattered light. The O.D. of the mounts is designed to provide a close fit within the nipple. This facilitates alignment along the axis of the laser beam while virtually eliminating the possibility of light scattering around the assembly. Four 4–40 tapped holes, equally spaced around the circumference at the base, allow one to fix, using set screws, the mount into the nipple. The (reduced) O.D. at the top of the mount will fit snugly within the I.D. at the base of another mount, thus allowing several mounts to be stacked. When more than one baffle is desirable, as is typically the case, the threaded holes at the base can be used to secure the mounts to each other using set screws.

Once the baffle is set within a holder, a retaining ring is slipped over the top portion and rests on the surface of the baffle itself. As can be seen in Figure 2, the cross section of the ring is tapered. This reduces the possibility of deforming the curved surface of the baffle. A second set of 4–40 tapped holes placed around the circumference fix the retaining ring, and thus, the baffle in place. By adjusting the travel of these set screws, baffles that are slightly asymmetric (as a result of a poorly formed base) may be centered.

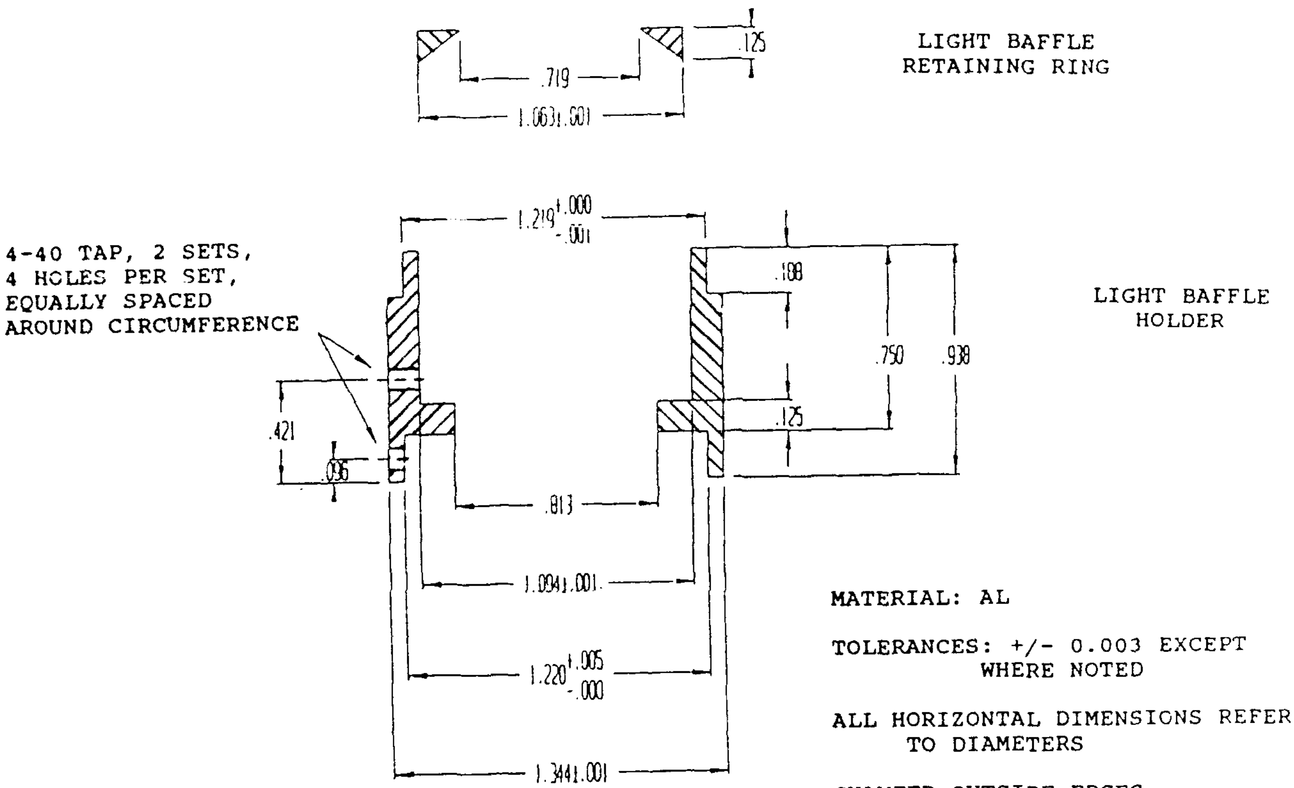

Figure 2. Cross Sectional Drawing of Two Piece Light Baffle Mount Consisting of Retaining Ring and Holder. All dimensions Are in Inches (1.00 Inch = 2.54 cm).

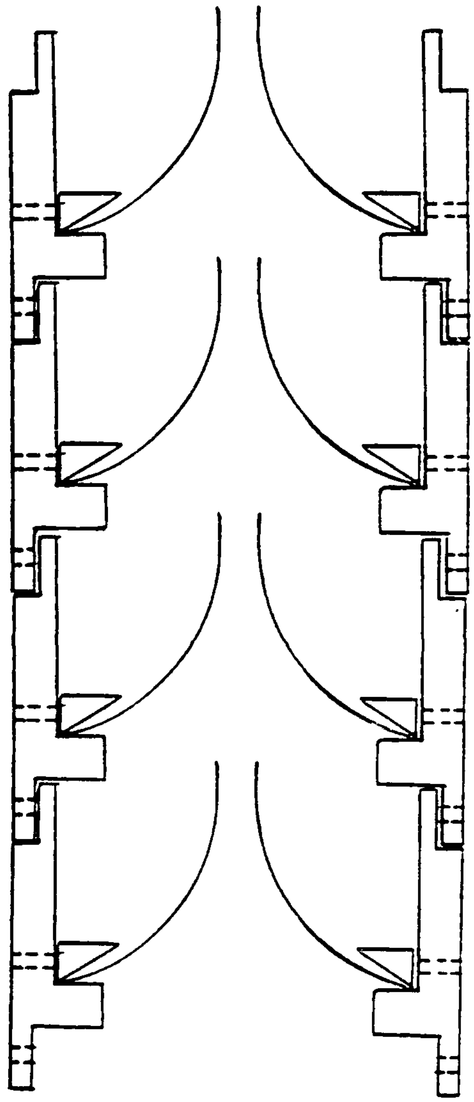

Figure 3. An Assembled Stack of Baffles in Mounts (Not Drawn to Scale).

Examination of an assembled mount/baffle set shows that the tip of the baffle projects only slightly from the top of the mount. Therefore, for the most part, the baffle is protected against accidental damage that may result (for example) from being dropped on the floor. (This particular safety feature was tested many times.)

After a stack has been assembled, alignment is accomplished by simply rotating individual sections until the apertures are aligned and then tightening the set screws located at the base of each section. A maximum of six mounts may be stacked and still fit within a single nipple. The entire stack is inserted into the appropriate nipple on the apparatus and fixed into place.

3. SUMMARY

All sections of the mounts described herein are interchangeable and all baffles are easily demounted and exchanged for ones of different size apertures. It should be obvious that the dimensions of these mounts (and baffles) could be adapted for use with an apparatus employing components of a different size. In summary, we have found this to be a simple, effective method of mounting these useful baffles.

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